CLAIMS

Having thus described our invention, what we claim as new and desire to secure by Letters Patent is as follows:

1. A method for digital printing represented as a matrix I, comprising:

forming a sequence of matrices P_k with entries 0 or 1 where a 1 at some entry in some P_k represents that this pixel will be printed at stage k;

constructing as sequences of matrices I_k with entries in [0, 1], so that $I_0 = I$;

determining, when considering all pixels in I_k for all succesive values of k, a next pixel having a largest weight indicating that said next pixel is to be printed next , so that P_{k+1} differs from P_k by a zero at said next pixel in P_k being replaced by a 1 at the same position in P_{k+1};

printing said pixel;

replacing the value of said pixel in I_k by a 0 thus forming I_{k+1}; and

incrementing the value of k, until enough pixels have been printed to represent the overall darkness of I by the printed image.

2. The method according to claim 1, wherein with each printing of a pixel, an order of printing of remaining pixels is redefined.

3. The method according to claim 1, further comprising reordering the pixels to be printed with each printing iteration.

4. The method according to claim 1, wherein an original image is denoted as said matrix $I = \{I(i, j)\}$, where $1 \leq i \leq$Himage and $1 \leq j \leq$Vimage, and

wherein each element $I(i, j)$ of I is a real number between 0 and 1 where 0 represents "white", 1 represents "black" and intermediate values represent levels of grey.

5. The method according to claim 4, wherein said matrix forming includes:

setting $k = 0$ and defining P_0 as the constant Himage by Vimage zero matrix.

6. The method according to claim 5, further comprising:

with each iteration of redetermining, replacing k by k+1; and

setting $I_k = I_{k-1}$ and $P_k = P_{k-1}$ except for a single pixel.

7. The method according to claim 6, further comprising:

determining whether there has been a change in $V(i, j, M_k)$;

computing all weighted averages $W(i, j, I_k)$ not computed in earlier iterations and setting $W(i, j, I_k) = W(i, j, I_{k-1})$ if $W(i, j, I_k)$ is not computed again, such that when k=1, all said weighted averages are computed, and for k>1, only said weighted averages which have been modified at a previous iteration are computed.

8. The method according to claim 7, further comprising:

ordering all $W(i, j, I_k)$ by decreasing order; and

considering $Max(k)$ as a larger value of all $W(i, j, I_k)$s.

9. The method according to claim 8, further comprising:

determining whether $W(i, j, I_k) = Max(k)$.

10. The method according to claim 9, further comprising:

for all pairs (i, j) such that $W(i, j, I_k) = Max(k)$, replacing $P_k(i, j) = 0$ with $P_k(i, j) = 1$ in P_k, and $I_k(i, j) = I(i, j)$ with $I_k(i, j) = I(i, j)-1$ in I_k.

11. The method according to claim 9, further comprising:

computing $GreyTotal(k) = \Sigma_{i,j} P_k(i, j)$.

12. The method according to claim 11, wherein if $GreyTotal(k) < GreyTotal$, then a next iteration is begun.

13. The method according to claim 11, further comprising:

if $GreyTotal \leq GreyTotal(k)$, and $|GreyTotal-GreyTotal(k)| < |GreyTotal-GreyTotal(k-1)|$, then set $P=P_k$.

14. The method according to claim 11, further comprising:

if GreyTotal $\leq$ GreyTotal(k), and |GreyTotal-GreyTotal(k)| $\geq$ |GreyTotal-GreyTotal(k-1)|, then set $P = P_{k-1}$.

15. The method according to claim 1, wherein a total number of black dots being printed is variable.

16. The method according to claim 15, further comprising:

providing a multi-tone printer, such that a lightest grey darker than Max(k) is printed, and $I_k(i, j) = I(i, j) - 1$ is replaced by $I_k(i, j) = I(i, j)$ which represents a multibit grey level being printed.

17. The method according to claim 9, further comprising:

compensating for isolated pixels by making weights in V(i, j, M) depend on what is printed at (i, j).

18. The method according to claim 1, further comprising:

encoding the set of pixels to be printed after half-toning, in the matrix P={P(i, j)}, where $1 \leq i \leq$ Himage and $1 \leq j \leq$Vimage, wherein each element P(i,j) of P has a value of either 0 or 1, where "0" represents "white" and "1" represents "black".

19. The method according to claim 18, further comprising:

given a Himage by Vimage matrix M with entries in [0,1], selecting a neighborhood V(i, j, M) for each (i, j), whose shape and size selectively depends or not on (i, j), and a set of weights associated to all pixels in V(i, j, M).

20. The method according to claim 19, wherein W(i, j, M) represents a weighted average of the elements of M in V(i, j, M), and GreyTotal= $\Sigma_{i,j}$ I(i, j).

21. A method of printing, comprising:

forming a matrix of pixels;

determining an order of printing of said pixels, said determining including finding a weight of said pixels and printing a pixel having a highest weight; and

reordering the remaining pixels and printing a pixel having the greatest weight of the remaining pixels until all pixels have been printed.

22. The method according to claim 21, wherein the pixels are printed in turn based on the darkness of the local image being printed.

23. A method for digital printing, comprising:

forming a sequence of matrices P_k with entries 0 or 1 where a 1 at some entry in some P_k represents that this pixel will be printed at stage k;

constructing as sequences of matrices I_k with entries in [0, 1], so that $I_0 = I$;

determining, for a plurality of pixels in I_k for all successive values of k, a next pixel having a largest weight indicating that said first pixel is to be printed next;

printing said pixel; and

determining for each pixel of the remaining ones of pixels of said plurality of pixels a printing order of said remaining pixels such that subsequent pixels of said remaining ones of pixels of said plurality of pixels having a largest weight among the remaining pixels, are subsequently printed.

24. A system for printing, comprising:

means for forming a matrix of pixels;

means for determining an order of printing of said pixels, said determining including finding a weight of said pixels and printing a pixel having a highest weight; and

means for reordering the remaining pixels and printing a pixel having the greatest weight of the remaining pixels until all pixels have been printed.

25. The system according to claim 24, wherein with each printing of a pixel, an order of printing of remaining pixels is redefined.

26. The system according to claim 24, wherein said reordering means reorders the pixels to be printed with each printing iteration.

27. The system according to claim 24, wherein an original image is denoted as said matrix $I = \{I(i, j)\}$, where $1 \leq i \leq Himage$ and $1 \leq j \leq Vimage$, and

wherein each element $I(i, j)$ of I is a real number between 0 and 1 where 0 represents "white", 1 represents "black" and intermediate values represent levels of grey.

28. The system according to claim 27, wherein said matrix forming means includes:

means for setting $k = 0$ and defining P_0 as the constant Himage by Vimage zero matrix.

29. The system according to claim 28, further comprising:

with each iteration of redetermining, means for replacing k by k+1; and

means for setting $I_k = I_{k-1}$ and $P_k = P_{k-1}$ except for a single pixel.

30. The system according to claim 29, further comprising:

means for determining whether there has been a change in $V(i, j, M_k)$; and

means for computing all weighted averages $W(i, j, I_k)$ not computed in earlier iterations and setting $W(i, j, I_k) = W(i, j, I_{k-1})$ if $W(i, j, I_k)$ is not computed again, such that when k=1, all said weighted averages are computed, and for k>1, only said weighted averages which have been modified at a previous iteration are computed.

31. The system according to claim 30, further comprising:

means for ordering all $W(i, j, I_k)$ by decreasing order; and

means for considering Max(k) as a larger value of all $W(i, j, I_k)$s.

32. The system according to claim 31, further comprising:

means for determining whether $W(i, j, I_k) = Max(k)$.

33. The system according to claim 32, further comprising:

for all pairs (i, j) such that $W(i, j, I_k) = Max(k)$, means for replacing $P_k(i, j) = 0$ with $P_k(i, j) = 1$ in P_k, and $I_k(i, j) = I(i, j)$ with $I_k(i, j) = I(i, j)-1$ in I_k.

34. The system according to claim 32, further comprising:

means for computing $GreyTotal(k) = \Sigma_{i,j} P_k(i, j)$.

35. The system according to claim 34, wherein if GreyTotal(k) < GreyTotal, then a next iteration is begun.

36. The system according to claim 34, further comprising:

if GreyTotal ≤ GreyTotal(k), and |GreyTotal-GreyTotal(k)| < |GreyTotal-GreyTotal(k-1)|, means for setting $P=P_k$.

37. The system according to claim 34, further comprising:

if GreyTotal $\leq$ GreyTotal(k), and |GreyTotal-GreyTotal(k)| $\geq$ |GreyTotal-GreyTotal(k-1)|, means for setting $P = P_{k-1}$.

38. The system according to claim 24, wherein a total number of black dots being printed is variable.

39. The system according to claim 38, further comprising:

a multi-tone printer for printing, such that a lightest grey darker than Max(k) is printed, and $I_k(i, j) = I(i, j) - 1$ is replaced by $I_k(i, j) = I(i, j)$ which represents a multibit grey level being printed.

40. The system according to claim 32, further comprising:

means for compensating for isolated pixels by making the weights in V(i, j, M) depend on what is printed at (i, j).

41. The system according to claim 24, further comprising:

means for encoding the set of pixels to be printed after half-toning, in the matrix P={P(i, j)}, where $1 \leq i \leq$ Himage and $1 \leq j \leq$Vimage, wherein each element P(i,j) of P has a value of either 0 or 1, where "0" represents "white" and "1" represents "black".

42. The system according to claim 41, further comprising:

given a Himage by Vimage matrix M with entries in [0,1], means for selecting a neighborhood V(i, j, M) for each (i, j), whose shape and size selectively depends or not on (i, j), and a set of weights associated to all pixels in V(i, j, M).

43. The system according to claim 42, wherein W(i, j, M) represents a weighted average of the elements of M in V(i, j, M), and GreyTotal= $\Sigma_{i,j}$ I(i, j).

44. The system according to claim 24, wherein the pixels are printed in turn based on the darkness of the local image being printed.

45. A signal-bearing medium tangibly embodying a program of machine-readable instructions executable by a digital processing apparatus to perform a method of printing, said method comprising:

forming a matrix of pixels;

determining an order of printing of said pixels, said determining including finding a weight of said pixels and printing a pixel having a highest weight; and

reordering the remaining pixels and printing a pixel having the greatest weight of the remaining pixels until all pixels have been printed.

46. A signal-bearing medium tangibly embodying a program of machine-readable instructions executable by a digital processing apparatus to perform a method of printing, said method comprising:

forming a sequence of matrices P_k with entries 0 or 1 where a 1 at some entry in some P_k means that this pixel will be printed at stage k;

constructing as sequences of matrices I_k with entries in [0, 1], so that $I_0 = I$;

determining, when considering all pixels in I_k for all successive values of k, a next pixel having a largest weight indicating that said next pixel is to be printed next , so that P_{k+1} differs from P_k by a zero at said next pixel in P_k being replaced by a 1 at the same position in P_{k+1};

printing said pixel;

replacing the value of said pixel in I_k by a 0 thus forming I_{k+1}; and

incrementing the value of k, until enough pixels have been printed to represent the overall darkness of I by the printed image.